# Regarding to Implementation of Genetic Algorithms in Life Cycle Management of Electrotechnical Equipment

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***Abstract*—Genetic algorithms regarding to life cycle management of electrotechnical equipment are considered. The concept of "techno-individual" is introduced.**

***Keywords*: life cycle, electrotechnical equipment, genetic algorithms, techno-individual.**

## I. Introduction

One of the solution techniques, allowing creating effective algorithms for a wide range of tasks, is the usage of a subclass of the directed random search methods – methods of genetic modeling.

Numerous approbation of use and application of genetic methods in scientific and industrial spheres allow saying with confidence that when using the evolutionary methods, realization of the comprehensible well-founded decision search problems is always reached. In overwhelming majority of cases the use of natural analogues gives positive results. This is explained by the fact that the analogue taken from the nature was improved for many years of evolutions and at the present time has the optimum structure [1].

The idea is to consider these genetic algorithms regarding to life cycle management of electrotechnical equipment.

Let's consider the main advantages of genetic algorithms usage:

- Ability to manipulate with many parameters at the same time;
- Good applicability when solving large-scale problems of optimization;
- Leniency of assumptions at a goal function estimation that expands a class of tasks which can be solved by means of genetic algorithms;
- Simplicity and "transparency" in implementation;
- Application in tasks with changeable place (adapting to changeable place);
- Ability to arrive at enough good solutions fast.

Genetic algorithms use direct analogy to the mechanism of biological development.

Like biological development each technological product develops continuously from a stage of origination (setting up) to a stage of collapse (recycling), going through any environment effects and adapting for them.

Algorithms work with a group of "individuals" – population, each of which represents possible solution of the given problem. Each individual is estimated by a measure of its "suitability" according to how rationally solution of the problem suits to it.

In each generation of the chromosome genetic algorithms (coded solutions) are the result of application of some genetic operations [1].

## II. The Key Genetic Relations Regarding Life Cycle Management of Electrotechnical Equipment

For description of the genetic algorithms when developing methods of the electrotechnical equipment' life cycle [2]-[6] estimation let's introduce some concepts.

*"Techno-individual"* – it's a type of any equipment (transformer, load etc), life cycling of which is considered with the view to biological evolution.

*Iinitial conditions* – datum values of the equipment parameters(for example, values of reliability including the level of the serviceability, revitalization, mean time between failures, probability of non-failure operation etc.).

*Principal criteria*, which are necessary to be followed, – to control the target level of the parameters values. It means that it is desirable during the resolution output to safe initial conditions with minimum costs.

*Characteristics*, defining the level of the organism development and its adjustment: possible methods of service, support of the set state, different from each other according to the degree of complexity and quality of execution.

Operations must precede the process of algorithms construction:

- Selection of the initial conditions;
- Criteria selection (criteria functions);
- Analysis and selection of the boundary conditions.

Selection operations of the initial level depend on the type of the current task and goals, which must be reached as a result of algorithm realization.

If it concerns maintenance of the parameters on the certain level and reliability index of the equipment in the course of its operation then as initial conditions it is reasonable to use data values of parameters and the indexes defined on a development stage in the form, installed by manufacturer and presented in the maintenance documentation (in particular, in maintenance documentation for the specific type of the equipment).

In this case, the main task is conformity «real reliability of the equipment – reliability set as zero conditions» that is support of higher level of reliability.

It is necessary to introduce criterion of an optimality estimation which will characterize level of considered solutions under the control of the technical state of the equipment [5][6].

Realization of the genetic algorithm assumes the fitness function. Input data of this function gets binary chromosome and returns the number, showing how good this chromosome is. The given function will be the criteria for the algorithm forming. In the embodied genetic algorithm it is reasonable at first to define the worse chromosome (having maximum deviations from the target level of parameter) and to measure the index value.

The got number is called the bad one with respect to which the quality of the other chromosomes is valued: fitness of the chromosome is calculated as difference between index value, set by the given chromosome and bad index value.

Let the chromosome is $X = x_1, x_2$ assigned with the value of the chosen index $n$ (for example, some index of the equipment sustainability) and the chromosome $Y = y_1, y_2$ with the index value $n'$. If $n'>n$, so $X$ – the worst chromosome, and $fitness(Y) = n' - n$.

As a result of these calculations each chromosome gets its fitness- number, which turns to be relatively small for the bad ones' and relatively big for the good ones', optimal reliability index, provided with given technologies.

Let, for example, have a look some time resolution, limited by the first equipment failure. So as a criteria it is reasonable to use the index value of the mean time between failure of the given type of high-voltage electrotechnical equipment. The highest the value of the criterion function, the more optimal is the method of the equipment maintenance , the more optimal is the set of methods, providing this maintenance and their content (the set of the actions, the level and the quality of their realization).

The criteria choice is the main preliminary step when building the algorithm, because only it will define the further algorithm filling, its logical direction and convergence.

One of the important moments is the analysis and the limitation selection of the given system and for the algorithm is its functioning. Limitation can absolutely different indeed:

Economic ones – in the network of the limited founding;

Technological ones – limitation in the instrument base and documentation base, skilled personnel and etc;

Temporal constraints – conducting the actions and etc.

Limitations are the necessary addition, which lets to take into account the particularities of the real technological objects and systems, factors, influencing on its activity. The majority of the real tasks have deterministic character.

Limitations can be also made as some rules and conditions and can be used when selecting and making the possible variants of solutions (heuristics).

The coding of the chromosomes is implemented according to the numbers of the methods, which are on the stage of "techno-individual" development.

In this case equipment is characterized by particular set of maintenances, with the help of which life cycle following is put into effect [6]. Each application for different methods can be done in different ways. And this is the difference in chromosome genes.

This difference will be: in application of various instrument base (for example, in one case optical resources are used at a visual estimation of a state of pendant basic insulators, and in other – there is nothing), taking into account some external factors, in application to various approaches concerning state estimation (up to distance and points control), and also in application to various methods of results processing.

It is necessary to add that all complex of actions should correspond to the circuit of support of the set technical state of the equipment (and to include not only actions for an estimation of the technical state in the form of monitoring and diagnostics, but also reducing and preventive operations etc.).

Changing of the purposes and the problems solved by system, can lead to revision as maintenances of preliminary operations, and a way of "filling" of chromosomes (for example, concerning economic aspect of a problem, the concepts connected with a given problematic and components can be used).

For the interpretation of genetic concepts concerning "techno-individual", the following definitions are introduced.

*Reproduction*. It includes some elements of standardization, as the developed techniques of service and decision-making. As a result of a reproduction we will receive element high voltage electrotechnical equipment and a set of the regulated actions by means of which its support and the control of its technical state will be carried out.

*Mutation.* In whole, a mutation – the ambiguous phenomenon in most cases calling negative consequences. In this case under mutation we will understand effect of some factors on equipment maintenance. To mutation factors we refer:

- Environment conditions (the external factor, in view of object distribution is important);
- Skills degree of operating staff.

*Crossover.* Refinement of existing techniques of the control and equipment service, on the basis of expert estimations and other sorts of the analysis of existing systems. Framing of concrete solutions on upgrading, support of any solutions of documentation base is necessary. The completion phase is development of the standard of the enterprise regulating and considering all features of a set of actions under the control and support of the set technical state of the equipment.

## III. Generic Flowcharts of Life Cycle of Electrotechnical Equipment

Generic flowchart of life cycle of electrotechnical equipment with the use of genetic algorithm theory is showed in the Fig. 1. On this Fig. 1 the next blocks are shown:

Block 1 – operation complex, corresponding to the concept of the genetic modeling reproduction (on this stage population initialization of "techno-individuals" or "techno-individual" for the private case is happening).

Block 2 – carrying out actions corresponding to the process of "techno-individual" ability to live.

Block 3 – complex of operations according to criterion assessment (fitness) of «techno -individual» (includes calculation of value of the selected goal function (fitness function) and an estimation of fitness level of every «techno -individual» according to the received values).

Block 5 – chain of operations and decisions, corresponding to the definition " survival rate" of the "techno -individual" (decision about possibility of its further vital capacity or life cycle end, if it is necessary).

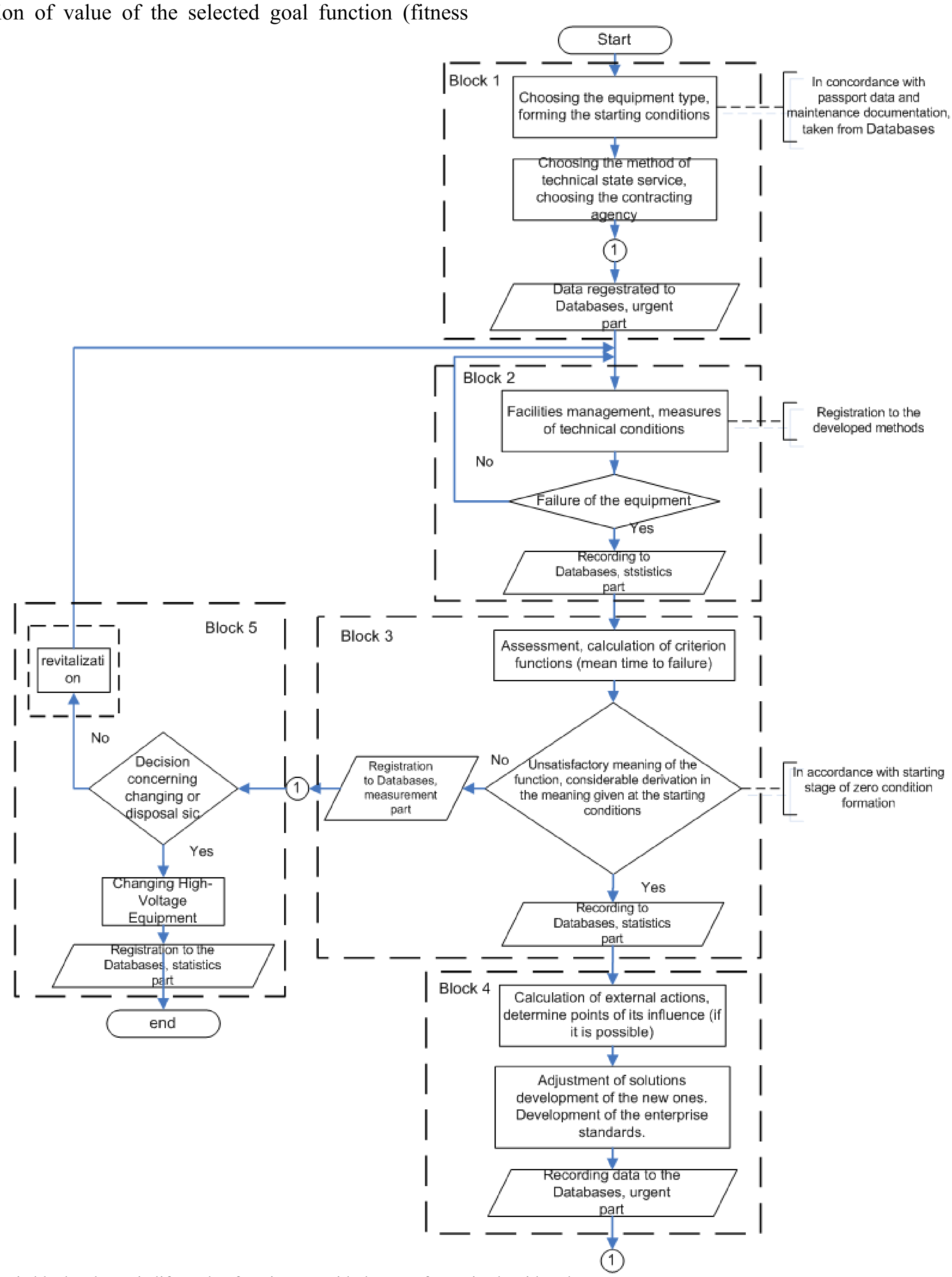


Fig.1. Generic block-schematic life cycle of equipment with the use of genetic algorithm theory.

The set of actions in maintenance and support of equipment life cycle will be the base for the formation of the possible variants (heuristics) for our task.

Let's separate some components of the scheme [7]-[10]:

*A* – Monitoring;

*B* – Diagnostics;

*C* – Maintenance, testing, measurements;

*D* – Failure control works;

In addition, let's add additional components:

*E* – Expert forecasting system of the technical state.

*F* – Integral estimate of the technical state.

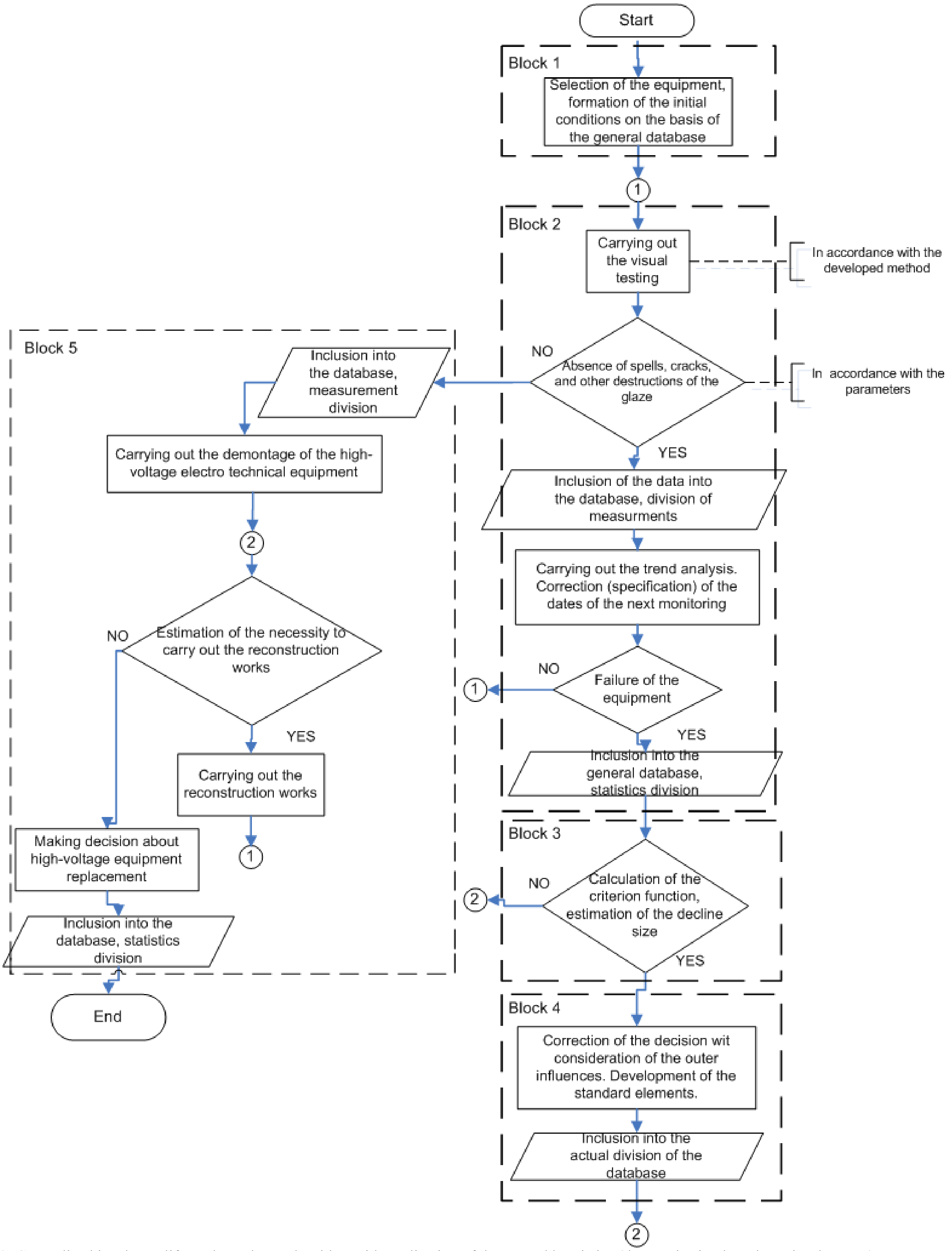


Fig. 2. Generalized insulators life cycle analyses algorithm with application of the second heuristics (the monitoring based on visual survey).

As a result of the primary sanction combinations in technical state control with additional ones will be get possible variants, which are heuristics :

$$H_1 = \{AE\},$$
$$H_2 = \{AF\},$$
$$H_3 = \{BE\},$$
$$\ldots,$$
$$H_8 = \{DF\}.$$

In the real task the number of combinations and their width can be much more. They can be added different preliminary set rules and conditions.

For example, let's have in more details the realization of the algorithm for the suspended insulators in the network of the simplify problem (Fig. 2).

The activities for quality control of the technical state are:

- Monitoring system [3];

− Diagnostics system [11].

Concerning the diagnostics we will decide that this action either take place ($A$) or not ($B$).

Regarding the system of monitoring several possible variants were suggested; let's have a look possibility of its implementation:

1 – monitoring by «hectic rush»;

2 – monitoring, based on the visual examination of the equipment;

3 – monitoring with the use of infrared and ultraviolet control;

4 – combined monitoring.

By variants combination we get 8 possible heuristics:

$$H_1 = \{1B\},$$
$$H_2 = \{2B\},$$
$$H_3 = \{3B\},$$
$$H_4 = \{4B\},$$
$$H_5 = \{1A\},$$
$$\ldots,$$
$$H_8 = \{4A\}.$$

The meaning of the blocks on the Fig. 2 fits the structure for the Fig. 1. Decomposition of the blocks 2 and 5 is more detailed, because it corresponds to the occurrence (monitoring high-voltage equipment on the base of visual examination). Moreover, block 2 is the base of the information fulfillment system (getting and analysis of the information, necessary for the following stages).

## IV. Conclusion

The difficulty and the goodness of action realizations in technical state of the equipment increases, the number of the operations required for the algorithm realization increases. But in spite of the apparent bulking, algorithms are simple in their accomplishment because of their coherency.

Electronic educational resources were developed using an educational process for training students with the specializations "Electrical Power Supply," "Automation of Technological Processes and Production," and "Automated Management of Product Life Cycle" of Perm National Research Polytechnic University [12].

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